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SCENARIO PREDICTION OF JAPANESE SOFTWARE INDUSTRY THROUGH HYBRID METHOD

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ABSTRACT

This paper aims at considering the possibility of the future scenario predictions of Japanese software industry through hybrid method. Thus, we try to preliminarily develop a new research framework by connecting the data obtained by large-scale fact-finding investigations, the statistical analyses results using the dynamic modeling, and the future scenarios of Japanese software industry through the simulation. First, we designed a large-scale social survey of the enterprise software industry in Japan, administered it, and developed a measurement tool of the software engineering capabilities with Ministry of Economy, Trade and Industry (METI). Second, we empirically verified that the human resource development of the IT firms improves the operational software engineering capabilities, and that the enhancement of the software engineering capabilities tends to improve the business performance of the IT firms in long term using the dynamic modeling. Third, we are trying to visualize the future scenario of Japanese software industry through the agent-based simulation.

This research includes the following original characteristics of academic research and expected results. First, the research suggests the guideline of the global technological strategy for Japan's software industry to ensure sustainable competitive advantage through the connection among large-scale social surveys, statistical analyses, and future prospects. Second, the research is a challenge for evidence-based visualization of industrial growth scenario by integrating society's intellectual caliber, which has evolved individually, such as fact-finding investigation conducted with METI, management theory, statistical analyses, and social simulation models. Third, the research has a possibility of evolving of the methods of designing for management of technology as a national strategy, from the viewpoint of management of technology, such as scale of players, technology paradigm shifts, global competitions and collaborations. Fourth, the methods through the connection among large-scale social surveys, statistical analyses, and future prospects, developed in the software industry in Japan can be expanded to any other sectors in any countries.

Keywords: software industry, innovation, social survey, statistical analysis, agent-based modeling

INTRODUCTION

Many companies in Japan that use enterprise software have not been fully satisfied with the quality, cost, and productivity of software that IT vendors deliver, or the speed of delivery. At the same time, IT vendors in Japan are facing drastic changes in their business environment, such as technological innovations and new entrants from emerging countries, e.g., China and India. Also, there are particular issues that are present in the IT industry in Japan, such as vendors relying on multilayer subcontractors and legacy business models that depend on

supplying custom-made applications for the domestic market. In fact, in 2009, the information service industry was a 10.5 trillion yen market in Japan, of which 7.6 trillion yen was for software development and programming. In 2009, orders for software totaled 6.4 trillion yen, accounting for 60.3% of the entire information service industry, while the software products market was 1.2 trillion yen (METI, 2010).

In order to meet these challenges in Japanese software industry, this paper aims at considering the possibility of the future scenario predictions of Japanese software industry through hybrid method by connecting large-scale social surveys, statistical analyses using the dynamic modeling, and the future scenarios of Japanese software industry through the simulation. First, we designed a large-scale social survey of the enterprise software industry in Japan, administered it, and developed a measurement tool of the software engineering capabilities with Ministry of Economy, Trade and Industry (METI). Then, we empirically verified that the human resource development of the IT firms improves the operational software engineering capabilities, and that the enhancement of the software engineering capabilities tends to improve the business performance of the IT firms in long term using the dynamic modeling. Second, we try to visualize the future scenario of Japanese software industry through the agent-based simulation.Then, we preliminarily developed a new research scheme to connect large-scale social surveys, statistical analysis results, and visualizing the future scenario of Japanese software industry.

LARGE-SCALE FACT-FINDING INVESTIGATIONS ON SOFTWARE ENGINEERING CAPABILITIES IN JAPAN

In order for the IT industry in Japan to meet the challenges as mentioned above, an important step is to understand how software engineering capability as a core competence for the industry is significant for achieving medium- and long-term success. Therefore, we designed a research survey on software engineering capabilities and administered it in 2005, 2006, and 2007, in collaboration with METI and Information-Technology Promotion Agency, Japan (IPA).
The objectives of the research were to:

- assess the achievements of the software engineering discipline, as represented by IT vendors in Japan, and
- better understand the mechanisms of how software engineering capabilities relate to IT vendors' business performance and business environment.

To achieve these objectives, we developed a measurement tool called Software Engineering Excellence (SEE), which can be used to evaluate the overall software engineering capabilities of IT vendors consisting of the seven factors: Deliverables, Project Management, Quality Assurance, Process Improvement, Research and Development, Human Resource Development, and Customer Contact based on interviews with industry experts and the literature searches (Barney, 2007; Carnegie Mellon University, Software Engineering Institute; Fujimoto, 2003; IEEE, Computer Society, 2004; Porter, 1980)
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We introduced two other indicators as well: Business Performance and Business Environment. Business Performance indicates the overall business performance of individual IT vendors, such as profitability, growth, productivity, and efficiency of the management. Business Environment expresses the company profile and structure of an IT vendor, e.g.,

origin of vendor, number of software engineers, average age of employees, business model, customer base, and corporate culture.

In the 2005 survey, there were 55 valid responses, a response rate of 24%, for the 2005 survey; and in the 2006 survey, there were 78 valid responses, a response rate of 15%. In the 2007 SEE survey, responses were received from 117 companies, with a total of 100 valid responses, a response rate of 10%. In the 2007 SEE survey, the sample size of each type of vendor, i.e., maker-turned, user-turned, and independent, was large enough to perform stratified analysis.

STATISTICAL ANALYSIS RESULTS ON RELATIONSHIPS BETWEEN SOFTWARE ENGINEERING CAPABILITIES AND BUSINESS PERFORMANCE

After collecting data from vendors in 2005, 2006, and 2007, we calculated the standardized factor loadings of the seven factors - Deliverables, Project Management, Quality Assurance, Process Improvement, Research and Development, Human Resource Development, and Customer Contact - through confirmatory factor analysis, based on the responses received to the questions relevant.

Regarding the cross-section analysis, on the basis of the data collected from 78 firms in SEE2006, we succeeded, by a trial and error method, in constructing a well-fitted path model (CFI = 1.0), where all the existing path coefficients are significant at the 5% level through the use of a atructural equation model (Bollen, 1989). We found that superior Deliverables and Business Performance correlate significantly with effort expended, particularly on Human Resource Development, Quality Assurance, Research and Development, and Process Improvement (Kadono, Tsubaki and Tsuruho, 2008).

In terms of the panel analysis results of software engineering capabilities, we integrated 233 valid responses to the SEE surveys received over three years into a single database and identified 151 unique IT firms, consisting of 42 maker-turned vendors, 33 user-turned vendors, and 76 independent vendors. Then we conducted panel analyses of the seven SEE factors, using the three years of data, to clarify what influence SEE factors have within a year, year-to-year, and mid-term. Based on the results of the panel analysis, our first observation is that most SEE factors in one year have significant positive influences on the same factors the next year. Second, within a year, there are three paths to improving the level of Deliverables, i.e., through Project Management, Quality Assurance and Research and Development. Third, some SEE factors have significant positive influence diagonally on different SEE factors in the following year. Fourth, there are some negative paths, implying that efforts put toward a particular factor do not pay off the duration of our research. Even so, these efforts might be expected to exert longer-term positive effects on other SEE factors (Kadono, 2011).

To understand the long-term relationships among the software engineering capabilities and business performance of the representative IT firms in Japan, we conducted longitudinal analyses on standardized software engineering capability scores of three surveys and ten-year business performance from 151 firms (Meredith and Tisak, 1990). Through the panel analyses, we found that IT firms maintaining high levels of deliverables, derived from high levels of human development, quality assurance, project management and process

improvement, tend to sustain high profitability, while IT firms with high levels of project management and customer contact tend to be highly productive and increasingly improve the productivity in the long-term. Concerning business performance, profitable IT firms tend to be stable and this tendency accelerates progressively due to the enhancement of deliverables and R&D. However, productive IT firms are not necessarily profitable likely because of the multi-layered industry structure in Japan (Kadono and Tsubaki, 2012).

NEW RESEARCH FRAMEWORK OF FUTURE SCENARIO PREDICTION

To consider the possibility of the future scenario predictions of Japanese software industry, we try to preliminarily develop a new research framework by connecting the data obrained by large-scale fact-finding investigations, the statistical analyses results using the dynamic modeling, and the visualization of future scenarios of Japanese software industry through the simulation.

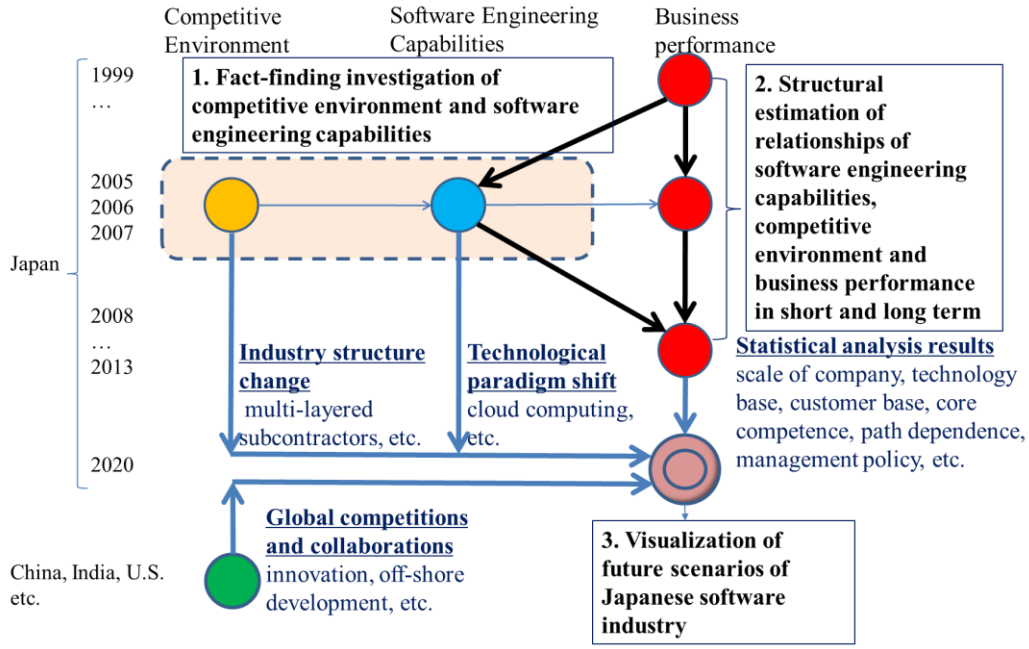

Figure 1: Connection of large-scale fact-finding investigations, statistical analyses and visualizing the future scenario of Japanese software industry

First, we try to understand the whole structure of the current Japan's enterprise software industry from the viewpoint of scale of company, path-dependency, software engineering capabilities, technological base, and customer base based on the fact-finding investigation and statistical analysis results as descrived above. Second, regarding Japan's enterprise software industry structure, we hypothesize that it is an unstable based on multi-layered industry structure consisting of large-scale system integrators, mid-sized software houses, and small temporary manpower companies. Third, the advanced technology paradigm is coming from the U.S. and other countries over the years, e.g., mainframe computer, client-server architechture, personal computer, internet, cloud computing. And Japan's enterprise software industry has fallen behind the U.S. and others. In other words, we think it predictable what advanced technology paradigm is coming next except the timing of the arrival from the

abroad. Fourth, global competitions and collaborations, such as off-shore developments in China, India, and other countries, have become active increasingly.

Then, we try to predict the future industry scenarios in 5-10 years, considering such four factors as statistical analysis results, industry structure changes, technological paradigm shifts, and global competitions and collaborations through the agent-based simulation (Epstein and Axtell, 1996). Here, we need to carefully experiment on the speed of the penetration of new technological paradigm into Japanese market, and the speed of changes of the cost structure in emerging countries as well as the improvement of communication levels between Japanese IT user companies and offshore vendors.

We preliminarily observed the tradeoff between the cost and the communication levels of IT vendors in Japan and China through the agent-based simulation (Kadono, 2011). This study aims at the preliminary assessment of the future software industry structure in Japan from the viewpoint of the influence of offshoring in China based on surveys on software engineering capabilities of Japanese IT vendors with the METI. Through the agent-based simulation model mainly focusing on customer's price preference and communication quality with customers, Japanese vendors can possibly lose their share of the market if Japanese customers prefer the lower prices offered by offshore vendors. The results suggest that Japanese vendors should improve their communication skill to realize the customer's requirements for the quality of enterprise software while avoiding the cost competition with the Chinese vendors and considering the customer's price preference. Otherwise, some Japanese vendors within the current multi-layered software industry culture will not survive in the drastically changing Japanese market.

CONCLUSIONS AND FUTURE WORK

This paper aims at considering the possibility of the future scenario predictions of Japanese software industry through hybrid method. Thus, we try to preliminarily develop a new research framework by connecting the data obrained by large-scale fact-finding investigations, the statistical analyses results using the dynamic modeling, and the future scenarios of Japanese software industry through the simulation.

This research includes the following characteristics of academic research and expected results and implications. First, the research suggests the guideline of the global technological strategy for Japan's software industry to ensure sustainable competitive advantage through the connection among large-scale social surveys, statistical analyses, and future prospects. Second, the research is a challenge for evidence-based visualization of industrial growth scenario by integrating society's intellectual caliber, which has evolved individually, such as fact-finding investigation conducted by METI and IPA, management theory including resource-based view, competitive threats, and the competitive advantage of nations, statistical analyses like dynamic covariance modeling, and social simulation models. Third, the research has a possibility of evolving of the methods of designing for management of technology as a national strategy, through visualization of optimistic to pessimistic scenarios. By doing this, we do not intend to prospect the future scenarios of the industry precisely, but we pursue deeply understanding the complex and multifaceted issues to be managed by policymakers and leading companies in the software industry in Japan, from the viewpoint of management of technology, considering scale of players, technological paradigm shifts, and global

competitions and collaborations, and so on. Fourth, the methods through the connection among large-scale social surveys, statistical analyses, and future prospects, developed in the software industry in Japan can be expanded to any other sectors in any countries.

We would like to extend our research to include the following future work:
- More precise estimation of population of software industry in Japan,
- More simulation analyses on the speed of the penetration of new technological paradigm into Japanese market, the speed of changes of the cost structure in emerging countries, and the improvement of communication levels between Japanese IT user companies and offshore vendors.

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